BROWSER-ENABLED REMOTE USER INTERFACE FOR TELECOMMUNICATIONS POWER SYSTEM

BACKGROUND AND SUMMARY OF THE INVENTION

The present invention relates generally to power systems for telecommunications equipment and networks. More particularly, the invention relates to a distributed user interface technology to simplify the operation and control of power supply systems for telecommunications and networking applications.

The power system of a typical telephone central switching station or Internet routing station is a complex, modular system employing one or more rectifier subsystems and one or more power distribution subsystems connected through a common bus. Also, many power supply systems today have a controller that coordinates the operation of the rectifier and distribution subsystems. Frequently telecommunications systems require backup power, which is typically supplied through a large bank of storage batteries.

Interacting with this complex assemblage of components has heretofore required a fairly high level of technical skill. Skilled engineers are expensive. When it is necessary to make adjustments to the power supply system, or to monitor operating parameters and make appropriate configuration adjustments, traditionally the engineer or technician must visit the site where the power supply system is located so that the operating conditions may be observed and appropriate action taken. While some large installations may have engineers or technicians on staff, many smaller installations, particularly those located in rural areas, are normally unmanned. While it is possible to schedule routine

maintenance visits to such remote sites, power supply systems for telecommunications equipment are also regularly subjected to electrical storms and other natural phenomena that create power outages on the electrical power grid to which the power supplies are connected. When AC power is lost due to a power outage, the power supply system will usually switch to reserve power, supplied by batteries or diesel-powered AC generators, or the like. Although the switchover to reserve power is automatic, the available reserve power is not endless. At some point, an engineer or technician may need to make a command decision as to which circuits will continue to be powered and which will be temporarily shut off. In the past, this would be done by making a personal visit to the site.

Electrical storms and other natural phenomena can sometimes create power outages over a widespread region. When such outages occur, it may become necessary for engineers and technicians to visit numerous sites, all within the time that reserve power is being maintained. When a large number of sites are without AC power due to an outage, engineers and technicians must work very efficiently. At such times, an easy to use, consistent user interface is a highly valuable asset.

There are, of course, numerous other situations in which an easy to use, consistent interface is desirable. For example, as the telecommunications system grows, additional loads may be added to the system, necessitating power supply system upgrades. In modular power supply systems, additional rectifier subsystems can be plugged in to increase the power delivery capacity. This may necessitate adding additional backup batteries, as well. When engineers or

technicians make such upgrades, they need a clear, easy to use interface through which they will set the operating parameters of the newly added equipment. If any real-time values, reflecting operating currents, voltages, temperatures and the like, are not within expected ranges, the engineer needs to be able to quickly identify the cause.

The present invention provides a remote user interface system that will allow a remote browser application to monitor and control the power system from anywhere in the world. The interface system further supports a local user interface, such as in the form of a liquid crystal display screen and touchpad interface, to provide the same information that is available through the remote browser. Preferably the local interface and the remote browser interface are configured as a series of menu screens providing both static and dynamic (real-time) information. Preferably the screens of the remote browser interface and the local interface are of the same or similar layout so that the user of the remote browser interface will be familiar with the local interface, and vice versa.

The remote user interface system employs a monitor and control system that is coupled to the electric power supply system for obtaining operating state information from at least one of the subsystems of the power supply. The monitor and control system also provides operating state information to at least one of the subsystems of the power supply. A data storage system associated with the monitor and control system stores the state information. A user interface manager is coupled for accessing the data storage system. In the preferred embodiment the user interface manager can both read from and write to the data

storage system, thereby datalogically linking the user interface manager with the power supply subsystems.

The user interface manager is operative to deliver an executable Java applet to the remote browser application. The applet generates a user interface within the browser application for monitoring and controlling the electric power supply system. In the preferred embodiment the user interface manager is configured to supply selected state information to the applet for display by the remote browser within the remote user interface. The user interface manager is further configured to receive data values generated by the applet in response to user interaction through the user interface. It communicates these data values to the data storage system for use in controlling the electric power supply system.

Further in accordance with the invention, the remote user interface system generates a plurality of linked pages containing both static text and/or graphical information and also dynamic (real-time) information. The real-time information reflects actual operating conditions within the power supply system, such as voltages, currents, temperatures, time intervals, and the like. This dynamically-displayed content also represents active regions with which the user may interact. For example, the user can select an active region, such as a voltage, by manipulating the user interface cursor until it points to that region. Then, by selecting or clicking on the region, a subsequent page is automatically displayed, showing additional static and/or dynamic information that has a potential bearing on the real-time data previously displayed. Thus, if the user wishes to ascertain why a particular operating voltage is too high, he or she

simply clicks on the displayed voltage value and a subsequent screen is displayed, showing control settings and other parameters that have an effect on that operating voltage. Thus the user interface is quite intuitive and easy to use.

For a more complete understanding of the invention, its objects and advantages, refer to the following specification and to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a front view of an exemplary electric power supply system, illustrating how the modular subsystems may be configured;

Figure 2 is a software layer diagram illustrating the software environment in which the presently preferred remote user interface system may be implemented;

Figure 3 is data flow diagram illustrating a presently preferred embodiment of the user interface system;

Figure 4 is a block diagram illustrating the inter-module interface whereby components of the remote user interface system communicate with one another;

Figure 5 is a set of user interface diagrams, illustrating how active and static regions are linked in the presently preferred remote user interface system and

Figure 6 is a data structure diagram illustrating the messaging technique employed by the remote user interface applet when communicating with the remote access module of a local master control unit.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

An exemplary power supply system is illustrated at **10** in Figure 1. The system of the illustrated embodiment employs a rackmount unit having mounting rails **12** that supports a common bus structure that includes a data bus **14** and a DC power bus **15** to which a plurality of individual power supply system components are attached. Illustrated in Figure **1** is a modular battery connection unit **16** connected through suitable heavy duty cables **18** to a battery supply **20**. A modular power distribution unit **22** houses a plurality of individual circuit breakers **24**, which supply operating power to the telecommunications equipment **26**. The system also includes a modular master control unit **28** and a plurality of modular rectifier units **30** (four rectifier units are illustrated in Figure 1).

The master control unit **28** has a local user interface, preferably in the form of a display panel **30**, such as an LCD panel and a touchpad pointing device **32**. The user interacts with the local user interface by manipulating the touchpad **32** to, in turn, manipulate the cursor **34** displayed on panel **30**. By tapping the touchpad or pressing the left and right selector buttons **36**, the user can select various menu screens to control the power supply system as will be more fully described below.

The master control unit is coupled through a suitable interface to a computer network such as the Internet. In Figure **1** the network has been generically illustrated at **36** and the master control unit is shown connected through a telephone interface jack **38** to the telecommunications unit **26**. While a telephone connection has been illustrated here, it will be appreciated that the

master control unit could be connected to network **36** by other types of connections.

In accordance with one aspect of the invention a remote user interface is provided through a suitable computer or workstation such as computer **40**. Computer **40** is attached to network **36** so that it may communicate with the master control unit **28** through the network connection provided. Computer **40** hosts a browser application, such as a web browser application, which in turn runs a remote user interface applet. The applet provides connectivity with the master control unit **28** and allows the user to fully interact with the control unit through the remote browser interface.

In the presently preferred embodiment, the power supply units illustrated in Figure 1 are designed for modular interconnectivity. Each of the modular units includes supporting hardware and software for communicating over data bus **14**. While the modular units are capable of peer-to-peer communication, the presently preferred embodiment places the primary control functions within the master control unit **28**. The reserve power unit **16**, power distribution unit **22** and rectifier units **30** are provided with processors, referred to as "neurons," that handle the monitoring, control and communications functions associated with these modules. The master control unit includes a more powerful processor that runs the controller software that coordinates operation of the other modules as well as providing the user interface functionality.

The presently preferred embodiment employs a networked connection between the processor of the master control unit and the neurons of the other modules that make up the system. Communication is effected over bus **14** using

the CAN bus protocol. The master control unit and each of the neurons associated with the other modules contain the necessary hardware and driver software for communicating over the CAN bus. Although other protocols may be used, the CAN bus protocol is presently preferred because it is relatively robust in the presence of electrical noise such as would be expected in a power system.

To better understand how the remote user interface works, an overview of the presently preferred software architecture for the master controller will be presented. Referring to Figure 2, the software architecture may be defined in terms of three interacting layers: low level layer **100**, real-time layer **102** and user interface layer **104**. Although other operating systems may be used, the presently preferred embodiment uses the QNX operating system which provides a real-time multitasking environment. The low level layer **100** consists of the low level drivers for communication and hardware interface, such as modem, Ethernet, RS-232, CAN, LCD display, pointing device, I/0 interface, flash memory, watchdog and trace/log. Layer **100** provides services to the real-time layer **102** through an application programming interface (API). In this way, applications running in the real-time layer may be decoupled from hardware platform dependence.

Real-time layer **102** provides monitor and control functions for each of the reserve power module, power distribution module and rectifier modules as well as plant voltage and current monitoring and control functions applicable to the entire power supply system. In addition, alarm condition monitoring and diagnostic functions and software upgrade functions are provided in real-time layer **102**.

User interface layer **104** provides the functionality for supporting both local and remote user interface control of the modules in the real-time layer **102**. The preferred embodiment implements remote access through a web-based user interface through either an Ethernet or modem connection using TCP/IP and modem drivers found in layer **100**.

The user interface layer and the real-time layer communicate through access to a shared database **107** that is administered by database manager **106**. Figure 4 illustrates how the various modules within layers **102** and **104** communicate via the database manager **106**. The database manager implements a "soft" data bus **108** which provides a communication backbone within the controller software. The soft data bus enables module plugability, making it easy to add additional modules when upgrading or enhancing the controller software. Modules connected to the database manager (and thereby connected to the soft data bus **108**) interact with each other by reading from and writing to the database **107** being administered by database manager **106**.

Thus if the user wishes to access an alarm diagnostic value, for example, the user would interact through the user interface manager **110** (a component within layer **104**) to read the alarm diagnostic values obtained from the database **107** by database manager **106**. The alarm diagnostic module **112** operating in conjunction with alarm input/output module **114** (a component within layer **102**) is responsible for writing values to database **107** that are accessed by the user interface manager when interrogating the alarm diagnostic conditions.

By way of further example, if the user wishes to ascertain the current power plant voltage, the user interface manager **110** is again used. This time the

user interface manager will request database manager **106** to obtain values stored in database **107** that have been written to the database by the plant voltage/current monitor and control module **116**. Similar connectivity is provided between the user interface manager and software upgrade module **118**, power distribution monitor and control module **120**, reserve power monitor and control module **122**, rectifier monitor and control module **124** and neuron manager **126**.

Figure 3 provides a different view of how the modules within the presently preferred software architecture interact with one another to provide the remote user interface functionality. Figure 3 is a dataflow diagram in which communication between modules is illustrated using interconnecting lines with double-headed arrows and in which associations or relationships between modules and/or components are shown by lines without arrows. Database manager **106** and its associated database **107** are illustrated in the center of the diagram. The user interface manager **110** and the various monitor and control modules **116**, **120**, **122** and **124** communicate with the database manager. The rectifier monitor and control module **124**, in turn, communicates with the rectifier unit **30**; reserve monitor and control module **122** communicates with the reserve power unit **116**; and distribution and control module **120** communicates with the distribution unit **22**. AC power is supplied from the AC mains to the rectifier unit(s) **30**, which in turn supply DC power over the DC power bus to both the reserve power unit **16** and the distribution unit **22**. Thus energy from the rectifier units is supplied to both power any loads attached to the distribution unit through breakers **24** and also to maintain the reserve power batteries at full charge. In the event the AC mains are lost, due to a power outage, the reserve power unit

16 supplies DC power via the DC power bus **15** to the distribution unit **22** so that the loads will continue to operate uninterrupted.

The user interface manager **110** supports both local and remote interface functionality. Local interface functionality is provided through a local graphical user interface (GUI) module **150** while remote user interface functionality is provided through a remote access module **152**. The remote access module will support multiple communication sessions concurrently. For each communication session a graphical user interface (GUI) daemon **154** is instantiated. The presently preferred remote user interface is designed to work using the TCP/IP protocol employed by the Internet. The GUI daemon **154** processes TCP/IP packets, packaging information sent by remote access module **152** over the network **36** and unpackaging packets sent to the remote access module from the network **36**.

The local GUI module **150** is designed to receive user input through a touchpad **32** having pushbuttons **36** to simulate the right and left mouseclick buttons of a computer graphical user interface. The local GUI **50** also works with display panel **30** on which a graphical cursor **36** is displayed. The user can make menu selections by manipulating the cursor using touchpad **32**. In the illustrated embodiment menus are accessible through a button **160** in the lower left-hand corner of the screen. The user can also select navigation buttons **162** that simulate the Home, Back and Forward buttons commonly found on web browsers. The user can also select displayed text that appears in the center portion of the display screen as at **164**. The displayed text can either be static text that does not change during system operation or dynamic text that does

change during system operation. Typically the dynamic text is tied to real-time values measured by one of the monitor and control modules (e.g. modules **116** **120**, **122** and **124**) or from the alarm and diagnostic modules (e.g. modules **112** and **114**).

Clicking on or selecting a dynamically displayed value, such as the float voltage value, for example, causes the user interface manager to display a different screen that is relevant to the float voltage value. Thus, clicking on the numeric value "-54.5" in the illustrated local display **30** would cause a new screen to be displayed showing other measured values and parameters that affect the float voltage. The user could then make changes to these settings by selecting new settings from a pull-down menu box or other graphical user interface input technique. The new setting would then be communicated through the user interface manager to the database manager **106** for entry into database **107**. The monitor and control module or modules that use this setting would then access the database to obtain the new setting and make adjustments to the appropriate modules as needed to effect the new setting. This could in turn cause changes in measured values (e.g., float voltage) which would be communicated by the respective monitor and control modules to the database manager for writing into the database **107**.

An exemplary set of user interface screens has been illustrated in Figure 5. From the main graphical user interface screen **200**, the user can navigate to a variety of different screens. Five subscreens are illustrated in Figure 5. Clicking on the dynamically displayed value for temperature compensation takes the user to screen **202** where various voltage thresholds can be set. Clicking on the

dynamically displayed load current value takes the user to the distribution module status list screen **204**. Clicking on the dynamically displayed rectifier current value takes the user to screen **206**, which shows the rectifier status list. Clicking on the dynamically displayed battery current takes the user to screen **208**, which shows the battery connection module status list. Clicking on static text regions such as the text reading "Load Current", "Rectifier Current" or "Battery Current" takes the user to the Current Thresholds screen **210**. In this screen the user can change current threshold settings by selecting radio buttons or by entering values in the text boxes illustrated. If desired, the local GUI module **150** (Fig. 3) can support a keypad entry device for entering numbers into the value fields such as those shown in screens **202** and **210** of Figure 5. Alternatively, a pop-up keypad applet can be displayed on the user interface screen, allowing the user to enter numbers by clicking on digits in the displayed keypad.

The remote user interface of the preferred embodiment is designed to simulate the functionality and appearance of the local graphical user interface. This is accomplished through a remote user interface applet. The remote user interface applet is a stored application program that may be stored in the master control unit **28** for distribution as needed. The applet may be stored in non-volatile memory within the controller, which may be optionally associated with the database manager **106** and database **107**. The remote user interface applet is shown in dashed lines at **220** in Figure 3 to illustrate that the applet may be stored in database **107** or within some other memory device such as a read only

memory ROM, flash memory or the like. Such memory is illustrated diagrammatically at **222** in Figure 3.

The remote user interface applet is downloaded by the user interface manager through the remote access module **152** to the workstation or computer **40**. Computer **40** may run a standard web browser and may be suitably connected to network **36** to support TCP/IP communication. If the connection to network **36** is by modem, additional PPP protocols may be used to establish the Internet connection. Once the remote applet is downloaded to computer **40** it runs in the memory of computer **40** as illustrated diagrammatically at **224**.

The remote user interface applet provides several functions. First, it generates the static display screens (text and graphics) to mimic the appearance of the screens on the local user interface. Of course, because computer **40** will typically have a larger display area than the local display, the remotely displayed user interface can have additional displayed content as well. The remote user interface applet is also involved in displaying dynamically generated information and for sending control information back to the master control unit. When the user wishes to read a value within the power supply system, or wishes to change a setting or value, used by the power supply system, the user interacts with the remote user interface screen. The applet, in turn, constructs a message that identifies not only the parameter or setting entered by the user, but also the screen descriptor and field identifier so that the context of the user's entry may be fully defined. The remote user interface applet then packages this message in a TCP/IP packet or series of packets and sends it through the network to the remote access module **152**.

Once received by the remote access module the associated GUI daemon **154** unpacks the TCP/IP message, extracts the enclosed message sent by the remote user interface applet and passes this information to the user interface manager. The user interface manager then interprets the message by parsing it into its constituent parts. At this point, the user interface manager uses the constituent part information the same way as it would use information from the local GUI module **150**.

Figure 6 diagrammatically illustrates how the remote user interface applet may package a request for information, such as a request for a particular voltage value stored in database **107**. The remote user interface applet generates screen **300**, which may have a screen identifier I.D. value of SCR **47**. The requested voltage value may be physically located in a dynamically changing field **302** at (X,Y) position (10, 5). The remote user interface applet would thus construct message **304** to embed the screen identifier, the X and Y position values, and optionally a setting or value to be communicated to the master control unit **28**. In this case, the particular message being sent is a request for information from the database. Thus a suitable request information code may be embedded in message **304**.

The remote user interface applet then packages message **304** within a TCP/IP packet **306** and the packet is sent over the Internet or other suitable connection to the remote access module **152** within the master control unit (Fig. 3). The GUI deamon **154** associated with the remote access module unpacks the message **304** and the user interface manager then parses the message to determine that the user is on screen **47** at X,Y location (10, 5). Because the

message is a request for information, the user interface manager passes the request to database manager **106** for a database lookup operation. The database manager obtains the current value of the requested information and passes it back to the user interface manager, which in turn passes the value to the remote access module **152**. The remote access module then, using the services of GUI deamon **154**, constructs a reply message **308** that contains the screen I.D., the X and Y values and the requested value obtained by database lookup. In the example illustrated in Figure 6, the requested information is a voltage: 54.4V.

The remote access module bundles message **308** within a TCP/IP packet or packets **310** and the packet is sent back to the remote user interface applet **224** so that the value may be displayed in field **302** of the display screen **300**. In this way, the remote user interface applet is able to obtain values reflecting current operating conditions from the master control unit. The applet can also send operating parameters, such as those input by the user through a suitable dialogue box, pull-down menu, radio button or the like. To send control values to the master control unit the remote user interface applet constructs a message similar to that shown at **304**, except that the command would be an instruction to write a value to the database and would provide the appropriate value as supplied by the user. The remote access module would then unpack the message at the master control unit and place that value in the database for use by the other modules.

From the foregoing it will be appreciated that the user interface of the invention provides a powerful graphical user interface for convenient control of

a power supply system by both a local operator and a remote operator through a suitable web browser. Because the remote user interface and the local user interface offer the same functionality, knowledge obtained at either a local facility or a remote facility is easily transferred to the other facility. Thus an engineer working at a local power supply site would readily be able to interact with the system through a remote web browser connection without having to learn a new user interface. By being able to interrogate a number of different facilities from a single web browser at a remote location, one engineer can now do the job of many. This can significantly lower the cost to operate a power supply system within a telecommunications operation.

While the invention has been described in its presently preferred form, it will be understood that the invention is capable of modification without departing from the spirit of the invention as set forth in the appended claims.